Simpson
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SERVICE

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CALIBRATION AND TEST PROCEDURES

MODEL 460 DIGITAL VOLT-OHM-MILLIAMMETER

PRELIMINARY ISSUE

NOTE: The final Model 460 Service Manual will contain the Theory of Operation, Wave Forms, and Voltages.

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CALIBRATION AND TEST PROCEDURES

MODEL 460 DIGITAL VOLT-OHM-MILLIAMMETER

I. GENERAL:

The following Test Procedures can be performed as an overall check on the Model 460 Digital Volt-Ohm-Milliammeter.

The operator should use CAUTION when testing the unit with HIGH VOLTAGES since these voltages can appear in unexpected places if a malfunction occurs.

II. TEST EQUIPMENT REQUIRED:

1. AC/DC Differential Voltmeter Standard, such as the Hewlett-Packard Model 741B, or finely adjustable DC power supply with differential voltmeter having the accuracy of the Model 741B.

2. Digital voltmeter (DVM), such as the Simpson Model 2700.

3. Wide range oscillator, such as the Hewlett-Packard Model 200CD.

4. Oscilloscope with a minimum bandwidth of 250 kHz.

5. Decade resistor box or selected 0.1% resistors having values as shown in Table III.

6. DC Power Supply having an adjustable output of 0-36 volts at 1.5 amperes.

7. Electronic Counter, such as Simpson Model 2725.

8. Power amplifier, such as the Bogen Model MO 100A.

9. Transformer with the following basic specifications:

   a. Frequency response from 100 Hz to 20 kHz.

   b. Capable of supplying 2.5 volts at 1 ampere for a primary potential of 115 volts maximum.

   c. Capable of supplying the following secondary voltages for a maximum primary source potential of 115 volts. 200 mV, 2 volts, 20 volts, 200 volts, 1000 volts.

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III. PRELIMINARY STEPS:

1. Connect all test equipment as shown in Figure 2.
2. Set the DC Standard for 0.15 volt output and allow to warm up for at least 30 minutes.
3. Set the Digital Voltmeter for measurements on the 10 volt range.
4. Set the Electronic Counter for measurement of 40 kHz ±100 Hz.
5. Model 460 to be tested should be set up as follows:
   a. Function switch to OFF position.
   b. Range switch to 200 mV position.
   c. Batteries removed.

IV. INITIAL ADJUSTMENTS & BATTERY CHARGER CHECK:

1. Connect the positive lead of the DVM to TP-A (Figure 1).
2. Turn the Model 460 function switch to DCV position. All readout tubes should illuminate.
3. Adjust the REG POT until the DVM reads 8.000 ±0.01 volt.
4. Measure TP-B with the DVM. The reading should indicate a voltage between +4.75 to +5.45 volts.
5. Press battery slide switch.
6. Voltage reading should increase from the value in Step 4 to a potential between 5.6 and 6.5 volts.
7. If outside the limits specified in Step 6, check components in battery charging circuit.
8. Connect the Electronic Counter lead to clock output at TP-C.
9. Adjust the CLOCK ADJ pot until the Electronic Counter reads 40 kHz ±100 Hz.
10. Remove all input leads of both the DVM and Electronic Counter from the Model 460 circuit.

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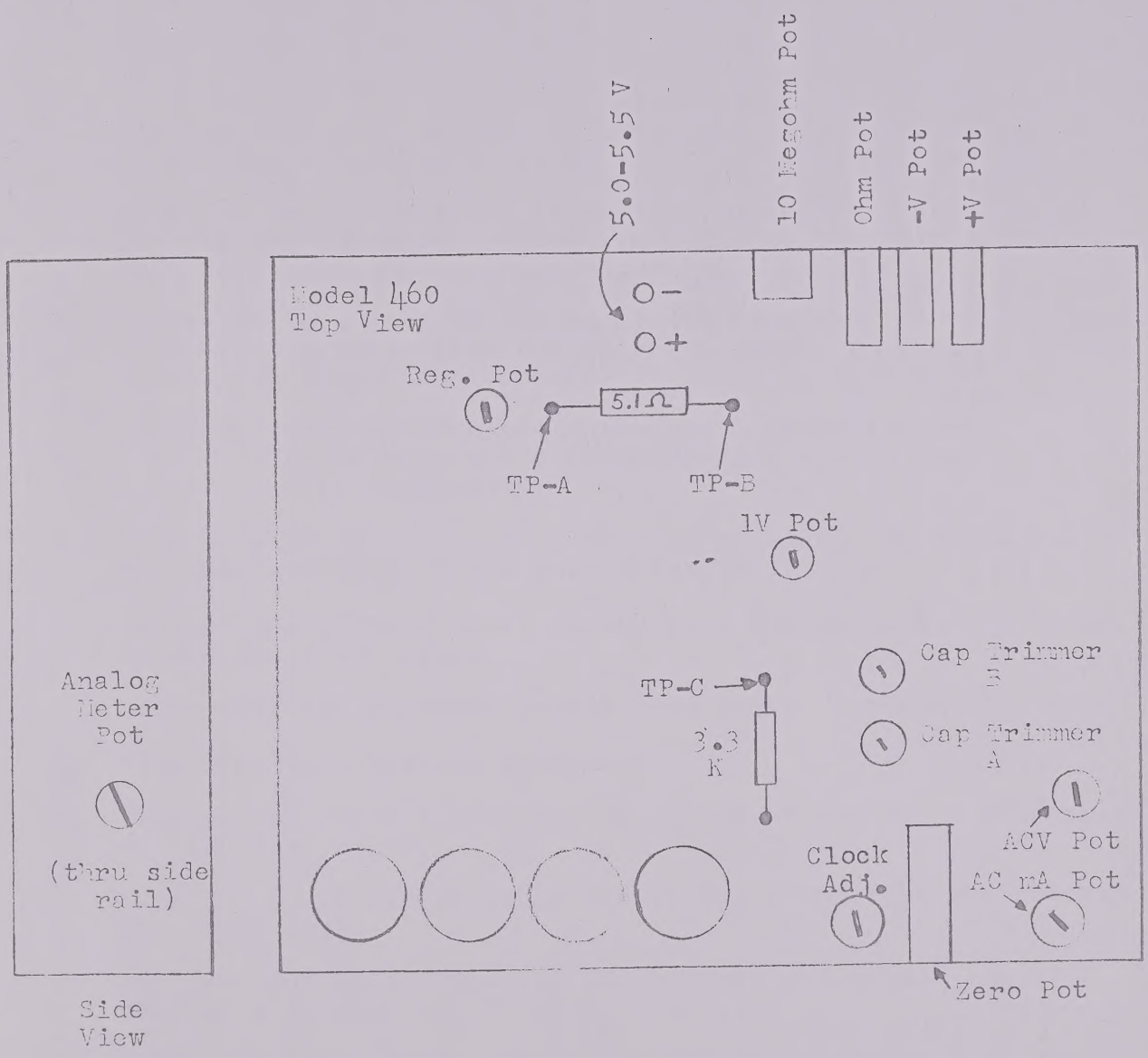
Figure 1

Test Points and Component Identification



NOTE: Use insulated screwdriver for all AC adjustments.

CALIBRATION AND TEST PROCEDURES
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V. ZERO ADJUST AND DC VOLT CALIBRATION:

1. With the V-OHM and COMMON terminals of the test unit shorted, adjust the ZERO pot on the front panel for a reading of ±00.0 counts.

2. Connect the two input leads of the test unit to the DC output of the AC/DC Standard.

3. With +0.1500 volt applied to the input terminals, adjust the +V pot for a reading of +150.0 ±1 count (Figure 1).

4. With the readout sitting at +150.0, adjust the analog meter pot with an insulated screwdriver through the hole in the side rail until the pointer reads 150.

5. Unplug AC line cord of the Model 460 from wall socket. Apply +5.05 to 5.5 volts from the DC Power Supply to battery holder + and - as shown in Figure 1.

   CAUTION: OBSERVE POLARITY CAREFULLY. REVERSING THE LEADS WILL CAUSE SEVERE DAMAGE TO THE CIRCUIT COMPONENTS.

6. Observe that the readout is displaying +150.0 ±1 count and no noticeable change on the Analog Readout.

7. Depress the BATTERY CHECK pushbutton; the meter should be well within the BATT. area.

8. Disconnect the DC Power Supply from battery holder.

9. Plug line cord into an outlet.

10. Reverse the input leads and adjust the -V pot for a readout of -150.0 ±1 count.

11. Turn the Model 460 range switch to the 2 position and reverse the input leads.

12. Apply +1.500 volts from the DC Standard and adjust the 1V pot for a readout of +1.500 ±1 count.

13. Short the input leads and rotate the range switch from the 200 mV to the 1000V range through each of the ranges. Observe the reading of each range respectively as follows: 00.0 ±1, .000 ±1, and 000 ±1.

14. Repeat Steps 1 through 13 if improper results are obtained.

continued. . . . . .

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VI. DC VOLT LINEARITY TEST:

1. Turn the Model 460 range switch to the 200 mV position.
2. Set up the AC/DC Standard for output voltages as shown in Table I.
3. Perform all steps and check the readout as indicated in Table I for both positive and negative polarities. Observe linear tracking of the Analog Readout.
4. Set up the AC/DC Standard for output voltages as shown in Table II.
5. Perform all steps and check the readout as indicated in Table II for both positive and negative polarities, of all other voltage ranges.
6. If indicated results are not obtained, repeat Steps 1 through 13.

VII. DIGIT TEST:

1. Set up the AC/DC Standard output at zero.
2. Turn Model 460 range switch to the 200 mV position.
3. Successively set the AC/DC Standard output controls so the third digit on the Model 460 will indicate from 0 through 9. It should readout within ±1 count of that shown on the standard. Be sure that all numerical digits are displayed for inspection.
4. Successively set the Standard output controls so the second digit will indicate from 0 through 9. It should readout the exact numerical value shown on the Standard.
5. Successively set the Standard output controls so the first digit will indicate from 0 through 9. It should readout the exact numerical value shown on the Standard.
6. Set the Standard for zero output.
7. The DC Voltage Test is complete.

continued. . . . . .

Figure 2

Model 460 DC Voltage Calibration

Test Connections

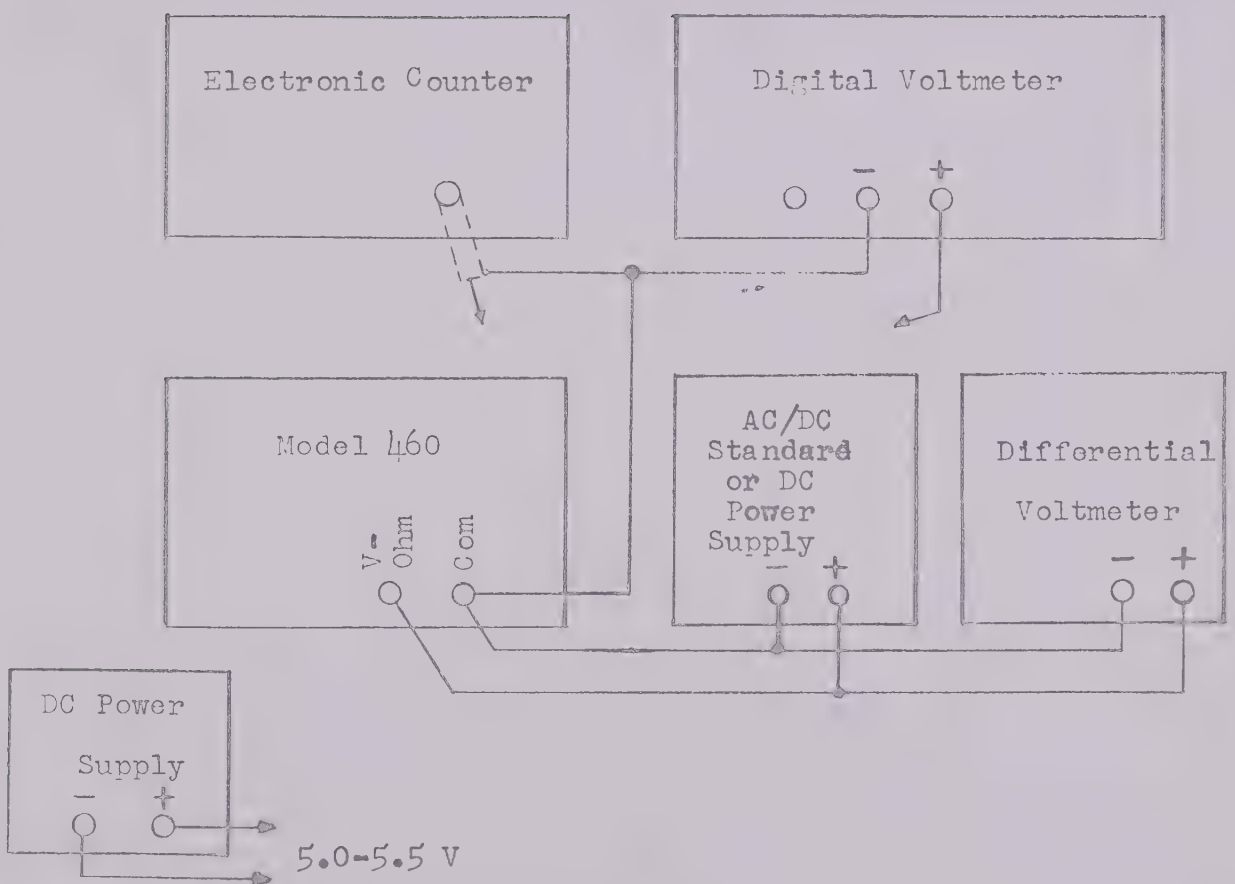

TABLE I

DC VOLT LINEARITY TEST - 200 MV RANGE

STEPS	AC/DC STANDARD OR DIFFERENTIAL VOLTMETER INDICATION	M-460 READOUT	M-460** ANALOG READOUT
1	.0000	00.0±1	0
2	.0100	10.0±1	10
3	.0300	30.0±1	30
4	.0500	50.0±1	50
5	.0700	70.0±1	70
6	.0900	90.0±1	90
7	.1000	100.0±1	100
8	.1200	120.0±1	120
9	.1400	140.0±1	140
10	.1600	160.0±1	160
11	.1800	180.0±2	180
12	.2000	*00.0±2	-----
13	.2300	*30.0±3	-----
14	.2500	*50.0±3	-----

* TOP HALF OF NUMERICAL 1 INDICATOR FLASHING.

** ACCURACY OF ANALOG READOUT IS ±½ of 1 DIVISION.

TABLE II

DC VOLT LINEARITY TEST

(2, 20, 200, and 1000 Volt Ranges)

STEPS	2V RANGE	20V RANGE	200V RANGE	1000V RANGE	M-460 READOUT
1	Short	Short	Short		000±1
2	0.500	05.00	050.0		500±1
3	1.000	10.00	100.0		1000±1
4	1.500	15.00	150.0		1500±2
5	1.900	19.00	190.0		1900±2
6	2.500	25.00	250.0		*500±3
				Short	000±1
				100.0	100±1
				300.0	300±1
				500.0	500±1
				700.0	700±1
				900.0	900±1

* TOP HALF NUMERICAL 1 INDICATOR FLASHING.

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VIII. DC CURRENT ACCURACY TEST:

1. Connect all test equipment as shown in Figure 3 with resistor values as shown for R1 in Table III, available separately or connected in the circuit with an appropriate switch.

2. Select a resistor value for R2 as determined by the power supply output voltage limits.

3. Set the Model 460 function switch to the DCmA position.

4. Insert a resistor for R1 on each range as indicated in Table III and adjust the power supply output for indication on the DVM of the voltages shown for each step in Table III.

5. The Model 460 should readout as shown in Table III.

6. This check should be made for both polarities by reversing the leads at the Model 460 input.

IX. OHMS CALIBRATION:

1. Connect all test equipment as shown in Figure 4.

   NOTE: SHIELDED AND LOW RESISTANCE, SHORT TEST LEADS SHOULD BE USED.

2. Set the Model 460 function switch to the K OHMS position.

3. Set the Model 460 range switch to the 20 position.

4. Set the Decade Resistor to 15.00K OHMS. Adjust the Ohm pot (Figure 1) on the rear of the unit for a reading of 15.00 ±1. Observe that the ± sign is inhibited.

5. Short the Model 460 input leads and observe a readout of 000 ±1 count.

   NOTE: A HIGH COUNT COULD MEAN EXCESSIVE LEAD RESISTANCE.

6. Set range switch to 20 MEGOHMS position.

7. Connect a 10 Megohm ±0.1% resistor across the input leads. Adjust the 10 Megohm pot on rear for appropriate reading.

continued. . . . . .

Figure 3

Model 460 DC Current

Test Connections

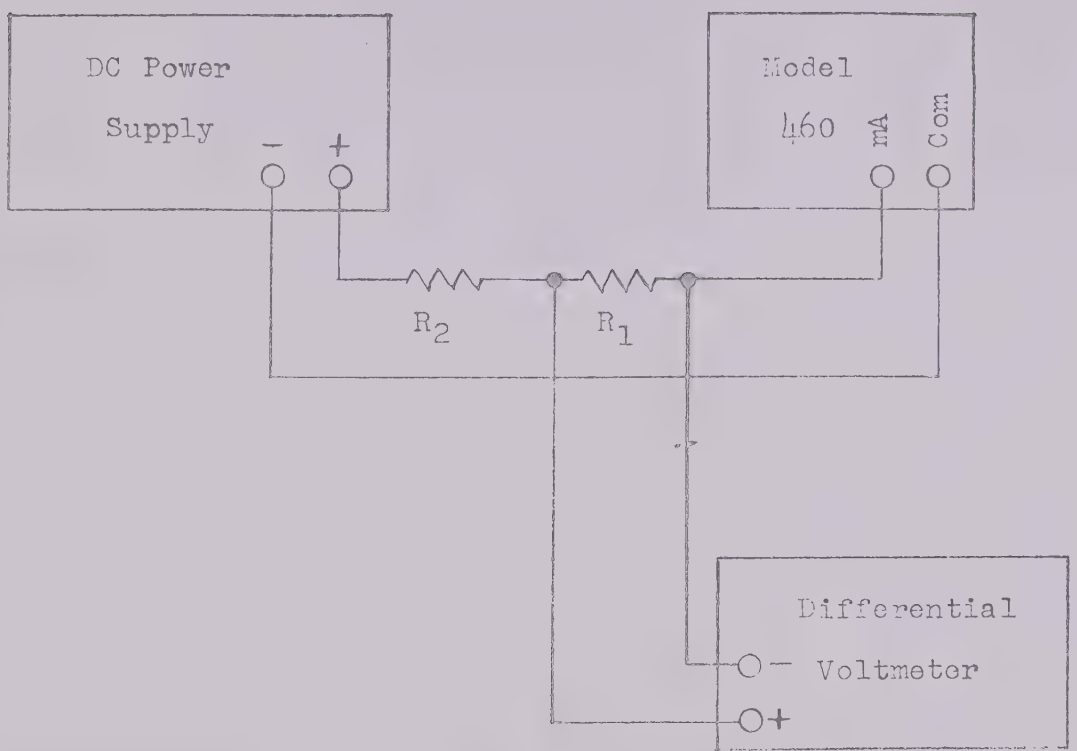

TABLE III

DC CURRENT ACCURACY TESTS

STEPS	DIFFERENTIAL VOLTMETER INDICATION (V)					** M-460 READOUT
	200 μA *R1 = 10,000 OHMS	2 MA *R1 = 1,000 OHMS	20 MA *R1 = 100 OHMS	200 MA *R1 = 10 OHMS	2 A *R1 = 1 OHM	
1	0.000	0.000	0.000	0.000	0.000	000±1
2	0.500	0.500	0.500	0.500	0.500	500±1
3	1.000	1.000	1.000	1.000	1.000	1000±2
4	1.500	1.500	1.500	1.500	1.500	1500±3
5	1.000	1.000	1.000	1.900	1.900	1900±4

* The values listed for R1 assumes that the differential voltmeter has negligable loading effect. If the instrument used has an input impedance of less than 100 Megohms, this resistor should be specially selected to eliminate errors. Each value combined with the input impedance of the instrument must have an accuracy of ±0.04% or better.

** This is the numerical readout. The decimal point should be present and positioned as required for the proper current readout value.

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X. OHM ACCURACY TEST:

1. Connect all test equipment as shown in Figure 4.

2. Set the Model 460 function switch to the K OHMS position.

3. Set the resistor decade box for values as shown in Table IV.

4. Perform all steps and observe the readout of Table IV for all the indicated ranges. Observe the correct positioning of the decimal points. On the 200 Ohm range, lead resistance of the input cable should be subtracted from all readings.

5. If proper readout cannot be obtained, repeat Steps 1 through 7 (IX).

XI. AC VOLTAGE CALIBRATION AND ACCURACY TEST:

1. Connect all test equipment as shown in Figure 5.

2. Allow all test equipment to warm up for 30 minutes.

3. Turn the Model 460 function switch to ACV position.

   CAUTION: TURN THE COURSE AMPLITUDE CONTROL TO MINIMUM BEFORE EACH RANGE CHANGE.

4. Turn the Model 460 range switch to the 2 position.

5. Set the oscillator for an output of 1.500V, 200 Hz as read on the differential voltmeter. Adjust the ACV pot on the printed circuit board (Figure 1) for a readout of 1.500 ±1 count.

   NOTE: FOR ALL AC ADJUSTMENTS, AN INSULATED SCREWDRIVER MUST BE USED. SEE NOTE IN FIGURE 1. USE OSCILLOSCOPE AS MONITOR TO MAKE SURE THERE IS NO CLIPPING OR DISTORTION AFFECTING CALIBRATION.

6. Turn the range switch to the 600 VAC position.

7. Set the oscillator for an output of 600V, 200 Hz as read on the differential voltmeter. Remember this readout for Step 8.

continued. . . . . .

Figure 4

Model 460 Ohms Calibration

Test Connections

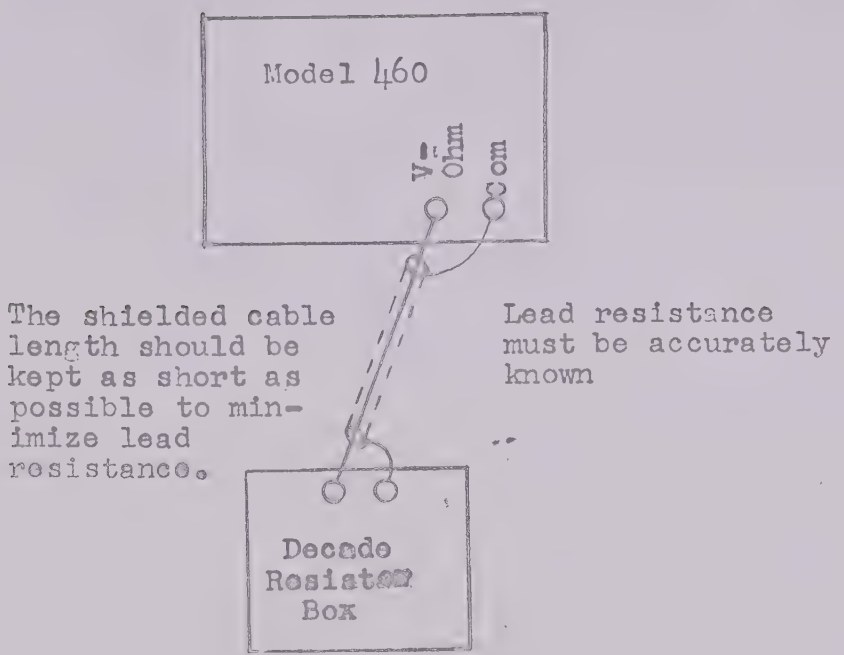
Model 460
V-Ohm
Com
The shielded cable length should be kept as short as possible to minimize lead resistance.
Lead resistance must be accurately known
Decade Resistor Box

TABLE IV

OHMS TEST

STEPS	RESISTOR DECADE SETTINGS					M-460 READOUT
	200 Ohms Range	2K Ohms Range	20K Ohms Range	200K Ohms Range	1000K Ohms Range	
1	Short	Short	Short	Short	Short	000±1
2	30.0 Ohms	300 Ohms	3.0K Ohms	30K Ohms	300K Ohms	300±2
3	70.0 Ohms	700 Ohms	7.0K Ohms	70K Ohms	700K Ohms	700±3
4	140.0 Ohms	1.4K Ohms	14.0K Ohms	140K Ohms	1400K Ohms	1400±5
5	190.0 Ohms	1.9K Ohms	19.0K Ohms	190K Ohms	1900K Ohms	1900±8
6	250.0 Ohms	2.5K Ohms	25.0K Ohms	250K Ohms	2500K Ohms	*500±10

* TOP HALF OF NUMERICAL 1 FLASHING.

8. Set the oscillator for an output of 600V, 20 kHz as read on the differential voltmeter. Adjust capacitor trimmer A for the reading from Step 7, and then set the amplitude control for zero output.

9. Turn the Model 460 range switch to the 200 position.

10. Set the oscillator for an output of 150.0V, 200 Hz. Remember the readout of the Model 460.

11. Set the oscillator for an output of 150.0V, 20 kHz as read on the differential voltmeter. Adjust capacitor trimmer B on the printed circuit board for the readout of Step 10.

12. Perform all steps and observe readouts as shown in Table V for all AC voltage ranges. Observe the correct decimal positions.

XII. AC CURRENT CALIBRATION AND ACCURACY TEST:

1. Connect all test equipment as shown in Figure 6 with available resistor values as shown for R1 in Table VI.

   NOTE: THE R1 VALUE LISTED ASSUMES THAT THE DIFFERENTIAL VOLTMETER HAS NEGLIGABLE LOADING EFFECT. IF THE INSTRUMENT USED HAS AN INPUT IMPEDANCE OF LESS THAN 100 MEGOHMS, THIS RESISTOR SHOULD BE SPECIFICALLY SELECTED TO ELIMINATE ERRORS. EACH VALUE COMBINED WITH THE INPUT IMPEDANCE OF THE INSTRUMENT MUST HAVE AN ACCURACY OF ±0.04%.

2. Turn the Model 460 function switch to the ACmA position.

3. Set the Model 460 function switch to the 200 position and insert a 10 ohm resistor for R1.

4. Set the oscillator output for an indication of 1.5V on the differential voltmeter. Adjust the ACma potentiometer (Figure 1) for an indication of 150.0 ±1 count.

5. Perform all steps and observe readouts as shown in Table VI. Observe correct decimal positions.

Figure 5

AC Voltage Measurements

Test Connections

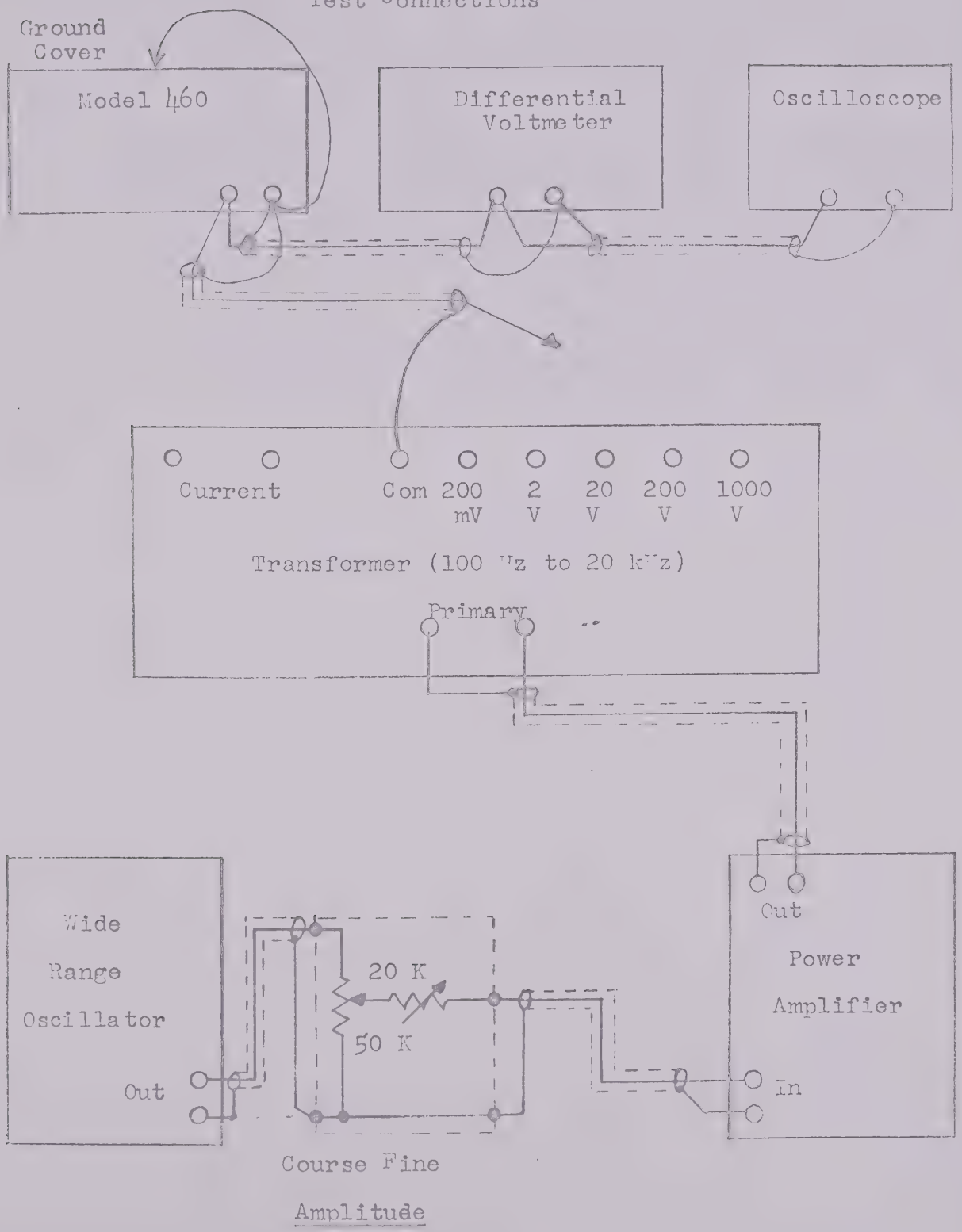

TABLE V

AC VOLTS ACCURACY TEST

STEPS	M-460 RANGE POSITION	VOLTAGE ON DIFFERENTIAL	M-460 READOUT FOR 100 Hz SIGNALS	M-460 READOUT FOR 20 kHz SIGNALS
1		Short	00.0±1	00.0±1
2	200 mV	.0300	30.0±2	30.0±3
3		.1000	100.0±4	100.0±8
4		.1900	190.0±8	190.0±15
1		Short	.000±1	.000±1
2	2 V	0.300	.300±2	.300±3
3		1.000	1.000±4	1.000±8
4		1.900	1.900±8	1.900±15
1		Short	0.00±1	0.00±1
2	20 V	03.00	3.00±2	3.00±3
3		10.00	10.00±4	10.00±8
4		19.00	19.00±8	19.00±15
1		Short	00.0±1	00.0±1
2		030.0	30.0±2	30.0±3
3	200 V	100.0	100.0±4	100.0±8
4		190.0	190.0±8	190.0±15
1		Short	000±1	000±1
2		100.0	100±2	100±2
3	* 600 V	300.0	300±3	300±3
4		600.0	600±4	600±5

* MAXIMUM VOLTAGE

Figure 6

AC Current Measurements

Test Connections

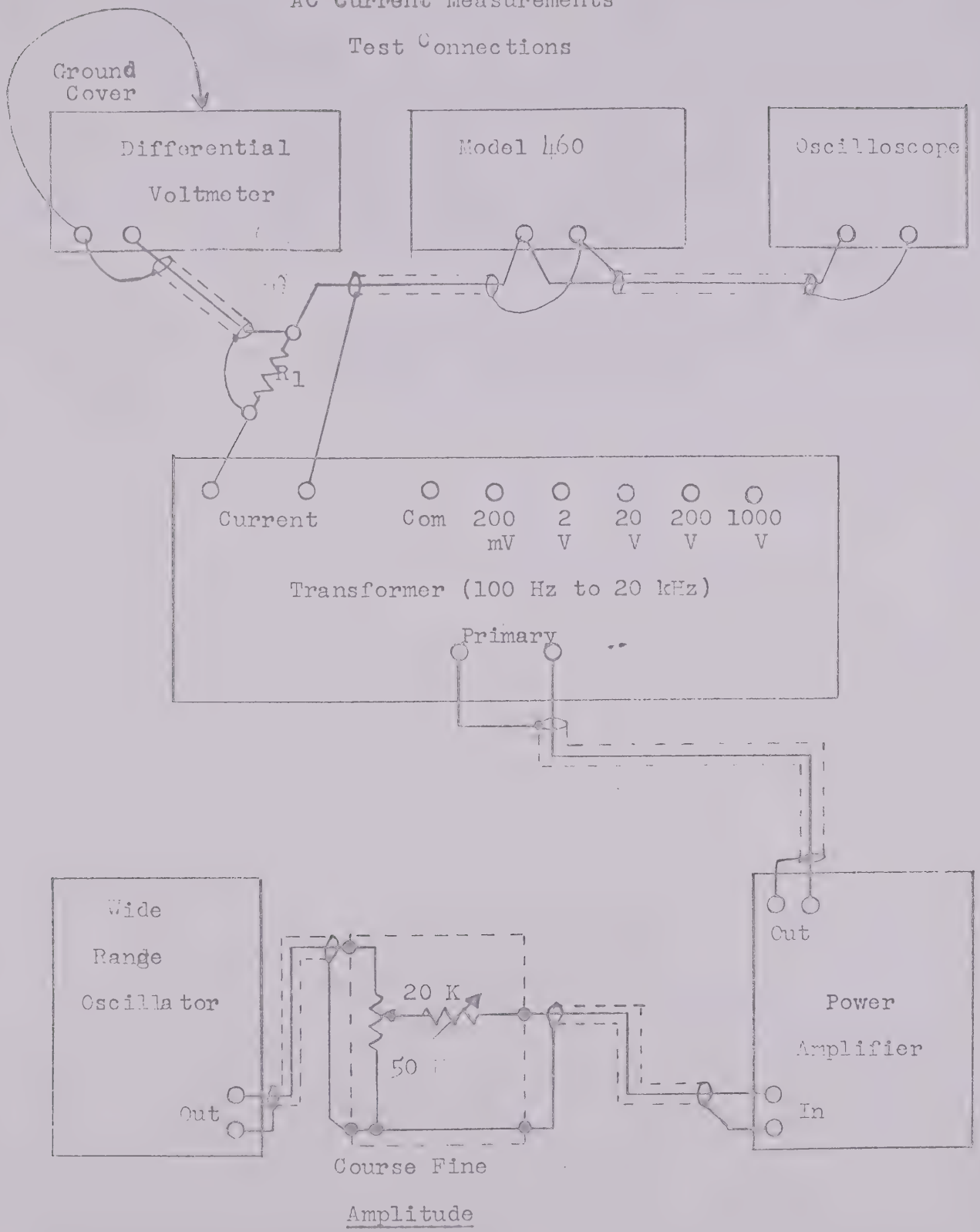

TABLE VI

AC CURRENT ACCURACY TEST

STEPS	M-460 RANGE POSITION	VALUE OF R1 *	AC VOLTAGE AS READ ON DIFFERENTIAL VOLTMETER	M-460 READOUT FOR 100 Hz AND 10 kHz SIGNALS
1	200 μA	10,000 Ohms	Short	00.0±1
2			0.800	80.0±4
3			1.800	180.0±8
1	2 MA	1000 Ohms	Short	.000±1
2			0.800	.800±4
3			1.800	1.800±8
1	20 MA	100 Ohms	Short	0.00±1
2			0.800	8.00±4
3			1.800	18.00±8
1	200 MA	10 Ohms	Short	00.0±1
2			0.800	80.0±4
3			1.800	180.0±8
1	1000 MA	1 Ohm	Short	00.0±1
2			0.800	800±6
3			1.000	1000±8

* The value listed for R1 assumes that the differential voltmeter has negligable loading effect. If the instrument used has an input impedance of less than 100 Megohms, this resistor should be specially selected to eliminate errors. Each value combined with the input impedance of the instrument must have an accuracy of ±0.04%.

MODEL 460 DIGITAL VOLT-OHM-MILLIAMMETER

TABLE VII

REPLACEMENT PARTS LIST

PART NUMBER	DESCRIPTION	SYMBOL
05-115537	CAPACITOR, ELECT., 300 uF, -10+75%, 6V	C1
05-115529	CAPACITOR, 0.1 uF, 10%, 630V	C2
05-112544	CAPACITOR, 5000 pF, 5%, 500V	C3
05-115527	CAPACITOR, TRIMMER, 15-60 pF, 350V	C4
05-115543	CAPACITOR, 430 pF, 5%, 600V	C5
05-115528	CAPACITOR, TRIMMER, 2-8 pF, 350V	C6
05-115165	CAPACITOR, 10 pF,5%, 2500V	C7
05-114521	CAPACITOR, 0.1 uF, -20+80%, 20V	C8,C9
05-115532	CAPACITOR, 1.8 uF, 10%, 250V	C10
05-115541	CAPACITOR, 91 pF, 5%, 300V	C11
05-113612	CAPACITOR, 0.1 uF, 10%, 100V	C12
05-113215	CAPACITOR, 0.01 uF, 20%, 100V	C13
05-114990	CAPACITOR, 22 pF, 5%, 500V	C14
05-113215	CAPACITOR, 0.01 uF, 20%, 100V	C15
05-111119	CAPACITOR, 0.001 uF, 20%, 1 kV	C16,C17
05-113217	CAPACITOR, 100 pF, 10%, 1 kV	C18
05-113215	CAPACITOR, 0.01 uF, 20%, 100V	C19
05-113985	CAPACITOR, 2500 pF, 20%, 1 kV	C20
05-115534	CAPACITOR, 15 uF, -20+50%, 16V	C21,C22
05-115540	CAPACITOR, 62 pF, +0.5 pF, 300V	C23
05-115534	CAPACITOR, 15 uF, -20+50%, 16V	C24,C25,C26
05-115539	CAPACITOR, 6 pF, +0.5 pF, 300V	C27
05-115534	CAPACITOR, 15uF, -20+50%, 16V	C28,C29
05-115530	CAPACITOR, 0.47 uF, 10%, 16V	C30
05-115531	CAPACITOR, 1 uF, 10%, 16V	C31
05-115533	CAPACITOR, 2.2 uF, 10%, 16V	C32
05-113216	CAPACITOR, 250 pF, 10%, 1 kV	C33
05-111119	CAPACITOR, 0.001 uF, 20%, 1 kV	C34
05-112588	CAPACITOR, 3300 pF, 5%, 600V	C35
05-111119	CAPACITOR, 0.001 uF, 20%, 1 kV	C36
01-110652	CAPACITOR, 0.02 uF, GMV, 500V	C37
05-115542	CAPACITOR, 510 pF, 5%, 500V	C38,C39
05-115534	CAPACITOR, 15 uF, -20+50%, 16V	C40
05-113215	CAPACITOR, 0.01 uF, 20%, 100V	C41,C42,C43
05-115538	CAPACITOR, ELECT., 3000 uF, -10+75%, 15V	C45
01-110652	CAPACITOR, 0.02 uF, GMV, 500V	C46
05-115535	CAPACITOR, ELECT., 1 uF, -10+75%, 16V	C47,C48
05-115536	CAPACITOR, ELECT., 15 uF, -10+75%, 25V	C49
05-114521	CAPACITOR, 0.1 uF, -20+80%, 20V	C50
05-115536	CAPACITOR, ELECT., 15 uF, -10+75%, 25V	C51
05-114521	CAPACITOR, 0.1 uF, -20+80%, 20V	C52

TABLE VII (cont'd.)

REPLACEMENT PARTS LIST - MODEL 460

PART NUMBER	DESCRIPTION	SYMBOL
05-115475	DIODE, A15F, 50 PIV, 3A	D1,D2,D3 D4
05-114946	DIODE, 1N456A, 25 PIV, 200 mA	D5,D6
05-112004	DIODE, 1N914, 75 PIV, 75 mA	D7,D8,D9
05-112721	DIODE, 1N825A, 6.2V	D10
05-112004	DIODE, 1N914, 75 PIV, 75 mA	D11
05-115476	DIODE, 1N750A, 4.7V	D12
05-112721	DIODE, 1N825A, 6.2V	D13
05-112004	DIODE, 1N914, 75 PIV, 75 mA	D14
05-114005	DIODE, 10D1, 100 PIV, 1A	D15,D16,D17 D18
05-111638	DIODE, 1N752A, 5.6V	D19
05-113197	DIODE, 1N751A, 5.1V	D20
05-114005	DIODE, 10D1, 100 PIV, 1A	D21,D22,D23 D24,D25,D26 D27,D28
05-112726	DIODE, 1N4743A, 5.6V	D29,D30
05-115413	TUBE, (-) (+) (1)	DS1
05-115415	TUBE, 0-9 WITH DECIMAL POINT	DS2,DS3
05-115414	TUBE, 0-9 WITHOUT DECIMAL POINT	DS4
05-115485	FUSE, PICO, 1/8A, 125V	F1
05-115486	FUSE, PICO, 3A, 125V	F2
01-113233	FUSE, ½A, 3AG	F3
05-115474	I.C., COUNTER/DRIVER, SCTR0110	IC1,IC2,IC3
05-115473	I.C., DUAL J-K FLIP-FLOP, SN74L73N	IC4
05-115472	I.C., DUAL D FLIP-FLOP, SN74L74N	IC5
05-115471	I.C., QUAD 2-INPUT HAND GATE, SN74L00N	IC6,IC7
05-115469	I.C., HEX INVERTER, SN74L04N	IC8
05-115473	I.C., DUAL J-K FLIP-FLOP, SN74L73N	IC9
05-115470	I.C., DIFF. COMPARATOR, LM710CH	IC10
05-115468	I.C., OPERATIONAL AMPLIFIER, LM308AH	IC11
05-115467	I.C., OPERATIONAL AMPLIFIER, TOA8709V	IC12,IC13
05-115484	TRANSISTOR, JUNCTION FET, LS5458	Q1
05-115483	TRANSISTOR, PNP, 2N4248	Q2
05-112631	TRANSISTOR, NPN, MPS3394	Q3
05-113864	TRANSISTOR, PNP, MPS3702	Q4
05-113035	TRANSISTOR, DUAL PNP, TD101	Q5
05-115478	TRANSISTOR, DUAL PNP, TD401	Q6
05-113193	TRANSISTOR, NPN, 2N4274	Q7,Q8,Q9
05-113864	TRANSISTOR, PNP, MPS3702	Q10
05-112631	TRANSISTOR, NPN, MPS 3394	Q11
05-113864	TRANSISTOR, PNP, MPS3702	Q12,Q13
05-115419	TRANSISTOR, NPN, 2N5172	Q14,Q15,Q16 Q17,Q18,Q19 Q20,Q21,Q22

TABLE VII (cont'd.)

REPLACEMENT PARTS LIST - MODEL 460

PART NUMBER	DESCRIPTION	SYMBOL
05-112631	TRANSISTOR, NPN, MPS3394	Q23,Q24
05-115482	TRANSISTOR, NPN, EN2222	Q25
05-115480	TRANSISTOR, PNP, D41D1	Q26
05-115709	TRANSISTOR, NPN, D44C2	Q27
05-115481	TRANSISTOR, NPN, 2N4921	Q28,Q29
05-115480	TRANSISTOR, PNP, D41D1	Q30
05-115479	TRANSISTOR, NPN, D40D1	Q31
05-115419	TRANSISTOR, NPN, 2N5172	Q32
05-111408	RESISTOR, 100K Ohms, 1%, ½W	R1
05-113623	RESISTOR, 22K Ohms, 10%, ¼W	R2,R3
05-111408	RESISTOR, 100K Ohms, 1%, ½W	R4
05-115526	RESISTOR, 90K Ohms, 1%, ¼W	R5
05-115502	RESISTOR, 4.99K Ohms, 1%, ¼W	R6
05-115520	RESISTOR, 5K Ohms, 10%, ½W	R7
05-115502	RESISTOR, 4.99K Ohms, 1%, ¼W	R8
05-115500	RESISTOR, 2K Ohms, 1%, ¼W	R9
05-115487	RESISTOR, 10 Ohms, 1%, 1/8W	R10
05-115491	RESISTOR, 2K OHMS, 1%, 1/8W	R11
05-115496	RESISTOR, 17.6K Ohms, 1%, 1/8W	R12
05-115506	RESISTOR, 100K Ohms, 1%, ¼W	R13
05-115582	RESISTOR, PRECISION DIVIDER	R14
05-115506	RESISTOR, 100K Ohms, 1%, ¼W	R15
05-115517	POTENTIOMETER, 500 Ohms, 20%, ½W	R16
01-117538	RESISTOR, 1M Ohms, 5%, ½W	R17
05-115515	RESISTOR, 8.2M Ohms, 5%, ¼W	R18
05-115524	POTENTIOMETER, 1M Ohms, 20%, ½W	R19
05-115578	RESISTOR, 900 Ohms, 1/10%, 3/4W	R20
05-115577	RESISTOR, 90 Ohms, 1/10%, 3/4W	R21
05-115576	RESISTOR, 9 Ohms, 1/10%, 3/4W	R22
05-115575	RESISTOR, 0.9 Ohms, 1/10%, 1¼W	R23
05-115574	RESISTOR, 0.1 Ohm, 1/10%, 1¼W	R24
05-115498	RESISTOR, 495K Ohms, 1/10%, ¼W	R26,R27
05-115492	RESISTOR, 9K Ohms, 1/10%, 1/8W	R28
05-115489	RESISTOR, 1K Ohms, 1/10%, 1/8W	R29
05-115525	RESISTOR, 49.9K Ohms, 1%, ¼W	R30
05-113623	RESISTOR, 22K Ohms, 10%, ¼W	R31
05-114976	RESISTOR, 6.8K Ohms, 10%, ¼W	R32
05-115521	POTENTIOMETER, 1K Ohms, 20%, 1/10W	R33
05-115494	RESISTOR, 8.45K Ohms, 1%, 1/8W	R34
05-115497	RESISTOR, 90K Ohms, 1/10%, 1/8W	R35
05-115493	RESISTOR, 9.96K Ohms, 1/10%, 1/8W	R36
05-115514	RESISTOR, 100K Ohms, 10%, ¼W	R37
05-114962	RESISTOR, 10K Ohms, 1%, ¼W	R38
05-115488	RESISTOR, 510 Ohms, 1%, 1/8W	R39
05-115516	POTENTIOMETER, 100 Ohms, 20%, ½W	R40

TABLE VII (cont'd.)

REPLACEMENT PARTS LIST - MODEL 460

PART NUMBER	DESCRIPTION	SYMBOL
05-115510	RESISTOR, 150 Ohms, 10%, ¼W	R41
05-113872	RESISTOR, 1.5K Ohms, 10%, ¼W	R42
05-114962	RESISTOR, 10K Ohms, 1%, ¼W	R43
05-114978	RESISTOR, 12K Ohms, 10%, ¼W	R44
05-114962	RESISTOR, 10K Ohms, 1%, ¼W	R45
05-115513	RESISTOR, 56K Ohms, 10%, ¼W	R46,R47
05-113872	RESISTOR, 1.5K Ohms, 10%, ¼W	R48
05-115490	RESISTOR, 1K Ohms, 1%, 1/8W	R49
05-115513	RESISTOR, 56K Ohms, 10%, ¼W	R50,R51
05-114977	RESISTOR, 8.2K Ohms, 10%, ¼W	R52
05-115505	RESISTOR, 30.1K Ohms, 1%, ¼W	R53
05-114962	RESISTOR, 10K Ohms, 1%, ¼W	R54,R55
05-113872	RESISTOR, 1.5K Ohms, 10%, ¼W	R56
05-115514	RESISTOR, 100K Ohms, 10%, ¼W	R57
05-115505	RESISTOR, 30.1K Ohms, 1%, ¼W	R58,R59
05-113624	RESISTOR, 10K Ohms, 10%, ¼W	R60
05-115513	RESISTOR, 56K Ohms, 10%, ¼W	R61
05-114977	RESISTOR, 8.2K Ohms, 10%, ¼W	R62
05-115499	RESISTOR, 825 Ohms, 1%, ¼W	R63
05-115519	POTENTIOMETER, 2K ohms, 10%, ½W	R64
05-113623	RESISTOR, 22K Ohms, 10%, ¼W	R65
05-115518	POTENTIOMETER, 1K Ohms, 10%, ½W	R66
05-115504	RESISTOR, 5.76K Ohms, 1%, ¼W	R67
05-115495	RESISTOR, 14.3K Ohms, 1%, 1/8W	R68
05-113875	RESISTOR, 33K Ohms, 10%, ¼W	R69
05-114977	RESISTOR, 8.2K Ohms, 10%, ¼W	R70
05-114978	RESISTOR, 12K Ohms, 10%, ¼W	R71,R72
05-114973	RESISTOR, 3.3K Ohms, 10%, ¼W	R73
05-113625	RESISTOR, 2.2K Ohms, 10%, ¼W	R74,R75
05-114973	RESISTOR,3.3K Ohms, 10%, ¼W	R76
05-115512	RESISTOR, 18K Ohms, 10%, ¼W	R77
05-115499	RESISTOR, 825 Ohms, 1%, ¼W	R78
05-115495	RESISTOR, 14.3K Ohms, 1%, 1/8W	R79
05-115523	POTENTIOMETER, 22K Ohms, 20%, ½W	R80
05-114973	RESISTOR, 3.3K Ohms, 10%, ¼W	R81
05-114978	RESISTOR, 12K Ohms, 10%, ¼W	R82
05-115519	POTENTIOMETER, 2K Ohms, 10%, ½W	R83
05-114978	RESISTOR, 12K Ohms, 10%, ¼W	R84
05-114973	RESISTOR, 3.3K Ohms, 10%, ¼W	R85
05-113625	RESISTOR, 2.2K Ohms, 10%, ¼W	R86
05-114978	RESISTOR, 12K Ohms, 10%, ¼W	R87
05-113875	RESISTOR, 33K Ohms, 10%, ¼W	R88
05-114973	RESISTOR, 3.3K Ohms, 10%, ¼W	R89
05-115509	RESISTOR, 22 Ohms, 10%, ¼W	R90
05-114973	RESISTOR, 3.3K Ohms, 10% ¼W	R91

TABLE VII (cont'd.)

REPLACEMENT PARTS LIST - MODEL 460

PART NUMBER	DESCRIPTION	SYMBOL
05-115513	RESISTOR, 56K Ohms, 10%, ¼W	R92
05-114977	RESISTOR, 8.2K Ohms, 10%, ¼W	R93
05-115513	RESISTOR, 56K Ohms, 10%, ¼W	R94
05-114977	RESISTOR, 8.2K Ohms, 10%, ¼W	R95
05-113621	RESISTOR, 15K Ohms, 10%, ¼W	R96,R97,R98 R99,R100,R101 R102,R103,R104
05-114977	RESISTOR, 8.2K Ohms, 10%, ¼W	R105,R106,R107 R108,R109,R110 R111,R112
05-115442	RESISTOR, 3.9M Ohms, 10%, ¼W	R113
05-115441	RESISTOR, 2.2M Ohms, 10%, ¼W	R114
05-113626	RESISTOR, 1.0M Ohms, 10%, ¼W	R115
05-115440	RESISTOR, 390K Ohms, 10%, ¼W	R116
05-115439	RESISTOR, 300K Ohms, 5%, ¼W	R117
05-115438	RESISTOR, 150K Ohms, 5%, ¼W	R118
05-115437	RESISTOR, 75K Ohms, 5%, ¼W	R119
05-115445	RESISTOR, 38.3K Ohms, 1%, ¼W	R120
05-115444	RESISTOR, 29.4K Ohms, 1%, ¼W	R121
05-115511	RESISTOR, 560 Ohms, 10%, ¼W	R122
05-113871	RESISTOR, 1K Ohms, 10%, ¼W	R123
05-115510	RESISTOR, 150 Ohms, 10%, ¼W	R124
05-115522	POTENTIOMETER, 2.2K Ohms, 20%, 1/10W	R125
05-115501	RESISTOR, 4.7K Ohms, 2%, ¼W	R126
05-115403	RESISTOR, 8.2K Ohms, 2%, ¼W	R127
05-115508	RESISTOR, 8 Ohms, 1%, 3W	R128
05-115507	RESISTOR, 5.1 Ohms, 1%, 5W	R129
05-113869	RESISTOR, 680 Ohms, 10%, ¼W	R130
05-115509	RESISTOR, 22 Ohms, 10%, ¼W	R131
05-114967	RESISTOR, 47 Ohms, 10%, ¼W	R132,R133
05-115446	POTENTIOMETER, 220K Ohms, 20%, 1/10W	R134
05-113623	RESISTOR, 22K Ohms, 10%, ¼W	R135
05-113875	RESISTOR, 33K ohms, 10%, ¼W	R136
05-115443	RESISTOR, 28.7K Ohms, 1%, ¼W	R137
05-113869	RESISTOR, 680 Ohms, 10%, ¼W	R138
05-113871	RESISTOR, 1K Ohms, 10%, ¼W	R139
05-115449	SWITCH, ROTARY, FUNCTION	S1
05-115448	SWITCH, ROTARY, RANGE	S2
05-115545	SWITCH, SPDT, SLIDE	S3
05-115588	SWITCH, DPDT, PUSHBUTTON	S4
05-115421	TRANSFORMER, POWER	T1
05-115556	TRANSFORMER, DC TO DC CONVERTER	T2
05-115555	SOCKET, READOUT TUBES	
[illegible]	FUSE HOLDER	
05-114854	CONNECTOR, BANANA JACK, RED	

TABLE VII (cont'd.)

REPLACEMENT PARTS LIST - MODEL 460

PART NUMBER	DESCRIPTION	SYMBOL
05-114855	CONNECTOR, BANANA JACK, BLACK	
01-110614	LINE CORD, POWER	
D-13852	METER ASSEMBLY	
05-115583	KNOB, RANGE AND FUNCTION	
05-115549	KNOB, HANDLELOCK	
05-115417	WINDOW, CONTROL PANEL	
05-113480	BUMPER, RUBBER FEET, BOTTOM	
01-117829	BUMPER, RUBBER FEET, REAR	

NOTE: ALL SEMICONDUCTORS ARE SILICON.

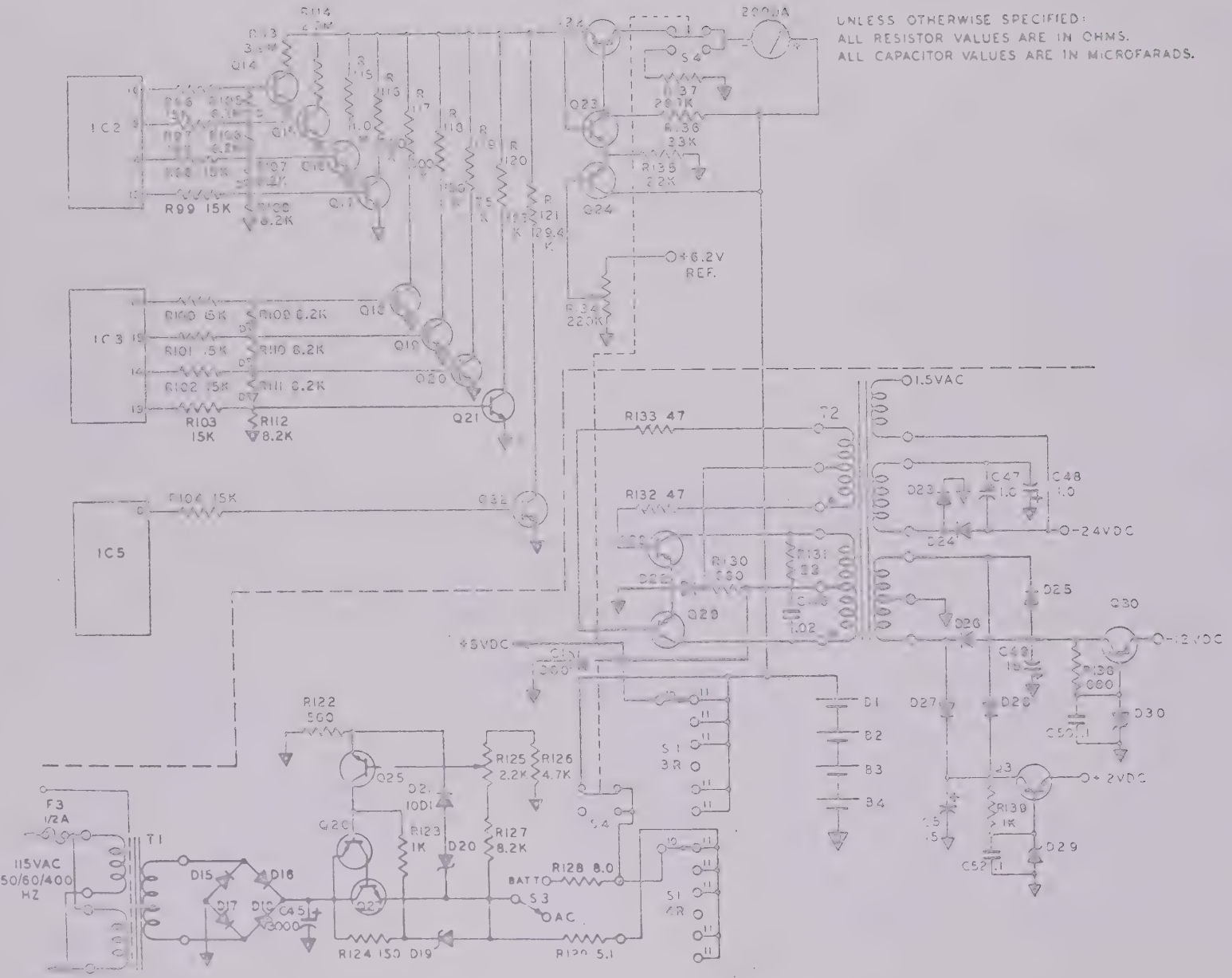

Figure 7, Power Supply and D/A Converter

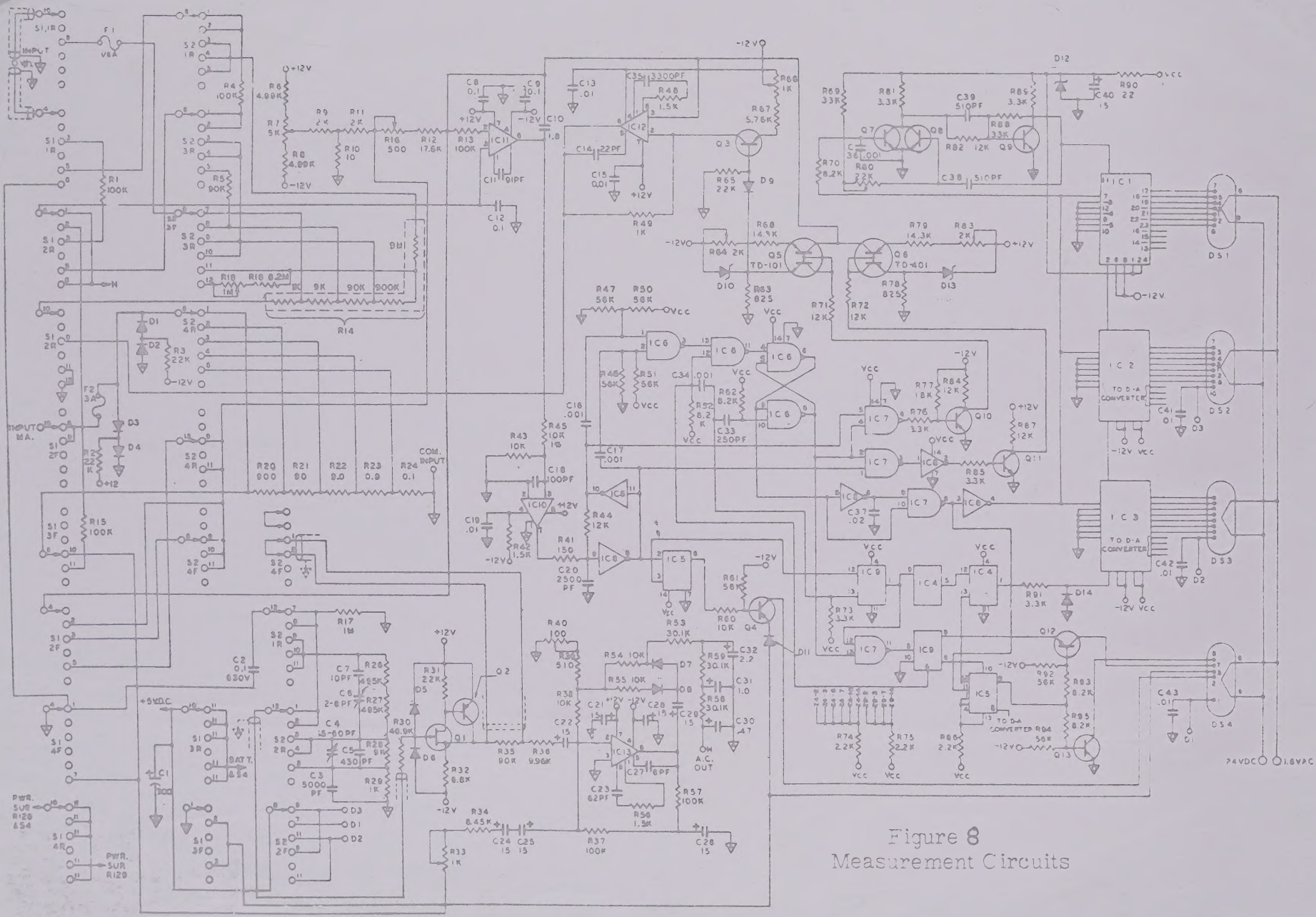

Figure 8
Measurement Circuits

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